Process Equipment Design
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Lecture –46
Design of Packed Column-4

Hello everyone. Welcome to the 10th week of the course Process Equipment Design and here we are in the 1st lecture of this week and here we are going to discuss design of packed column. So, if you remember the last lecture of last week that is the 9th week there we have design the packed column and we have calculated height as well as diameter of the packed column.

And in this particular lecture we will discuss the columns internals, how to decide the proper type of internals. So, let us focus on that. First of all we will discuss what is column internal?

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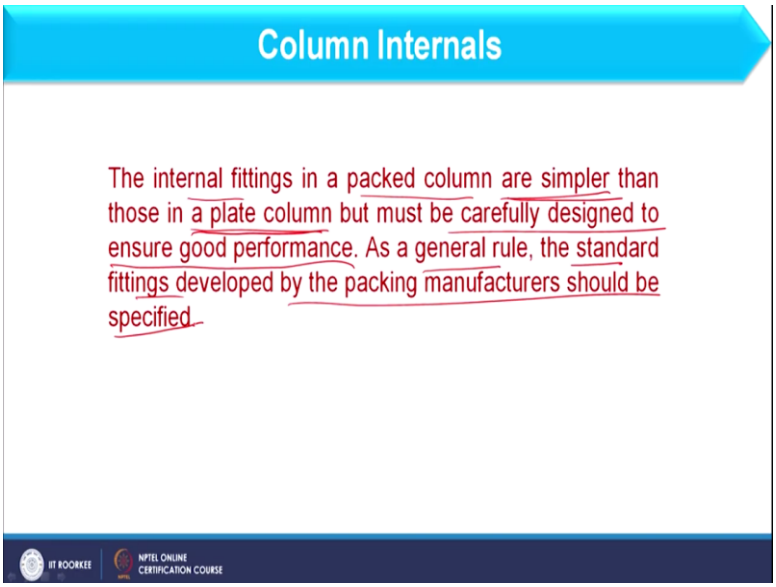

So, as far as internal fittings in the packed column are considered these are simpler in comparison to that we consider in plate column and it must be carefully designed to ensure good performance. So, what these internals are? These internals are basically liquid and gas distributor, packing support and we can have hole plates also. So, all these we consider apart from packing in the column and that we consider as the column internals.

So, design of these internals as well as selection of these internal should be done very carefully and for that we have some standards also. So, as a general rule standard fittings

developed by packing manufacturers should be specified. So, in this case we should consider the standard that in which particular case, which type of internal should be used. So, let us discuss first the packing support.

So, as far as packing support is concerned what is the meaning of that? That we also have discussed in previous lecture about the packed column that it is basically used to hold the packing. So, depending upon the packing size we should choose the packing support very carefully so that packing should stay over here, it should not pass through the holes available in the packing support.

And finally it should be based on the pressure drop because in the packing we can have the holes and through these holes liquids and vapour both will pass and they should not put any hurdle in the passing of liquid as well as gas.

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So, packing support should be properly selected and for that we can have some points as the function of the support plate is to carry the weight of the wet packing while allowing free passage of gas as well as liquid. So, as far as this packing support is concerned it should hold the liquid along with the weight of the packing. So, we can consider that as wet packing. So, these requirements conflict and poorly designed support will give a high pressure drop.

And can cause local floodings also because if it will not allow liquid to pass through it continuously accumulation of liquid occurs in the bed and which will cause the flooding. So, usually we consider simple grid and perforated plate which is used as a support, but in these

designs the liquid and gas have to pass through from the same opening. So, wide spaced grids are used to increase the flow area with layers of larger size packing stacked on the grid to support the same size random packing.

So, what is the meaning of this all these points will be clear when we discuss the schematic in the next slide, but you should understand that at the bottom we should have the packing support of larger size because it should let the liquid and gas to pass through it and because of this larger opening in the support packing should not pass through it. So, we basically consider larger size packing over this and over that we consider small size packing.

And that is preferably used in random packings. So, best design of support plate is one in which gas inlets are provided above the gas level where liquid flows from the bed such as gas injection type. So, what is this gas injection type that also we will discuss.

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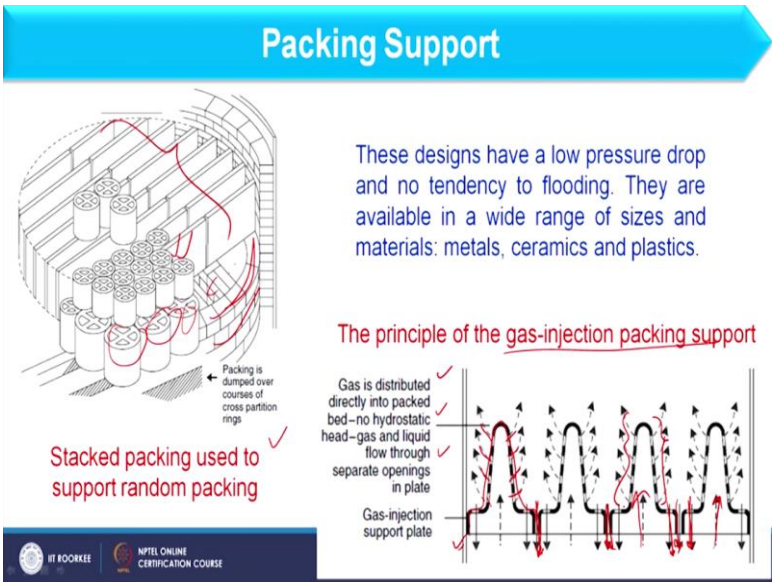

So, here you see I am having this stacked packing used to support random packing. So, if you see this is basically the packing support and here we have different holes and over that we basically consider large size packing. And further we consider small size packing over this. So, in this way you can have the packing support. So, this is basically the support and we can have the gas injection packing support like if you consider this is basically the gas injection support plate where we can have this type of assembly.

And in between we can have the hole for gas to move and in between this we can have the moment of liquid also. So, liquid can pass through this, but it will not interfere the flow of

gas. So, gas is distributed directly into the packed bed no hydrostatic head, gas and liquid flow through separate openings in the plate as I have already discussed these are basically for liquid and here we have this gas moment.

Liquid can also fall from this, but it will not hinder the moment of gas through this packing support. So, in this way gas injection packing support works and now we will discuss the liquid distributors. So, what is the purpose of liquid distributor is it properly distributes the liquid throughout the cross sectional area of the column. So, what the design available for that let us discuss that.

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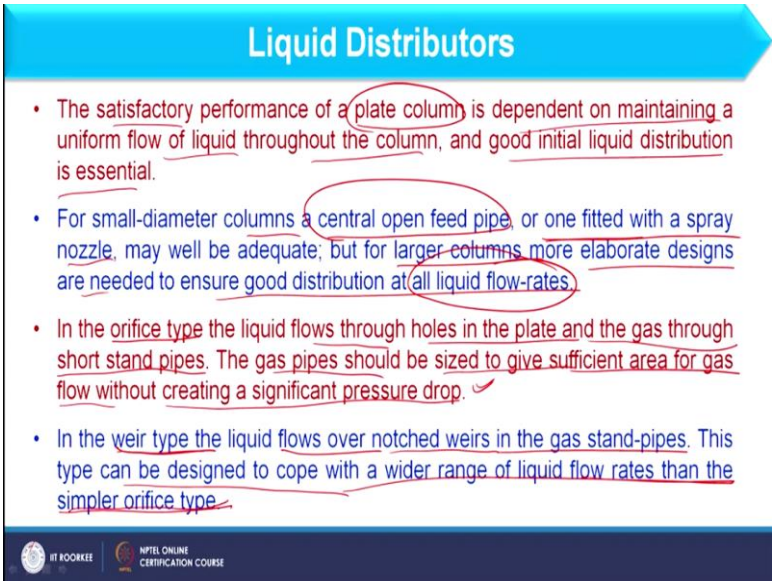

So, the satisfactory performance of the packed column is dependent on the maintaining a uniform flow of the liquid throughout the column and good initial liquid distribution is essential. In this we can consider a center open feed pipe or one fitted with the spray nozzle and through these nozzles liquid can be properly distributed in the packing when the column diameter is small.

So, one opening is enough for that, but for larger diameter column more elaborate designs are needed to ensure good distribution of liquid when I am having all liquid flow rates. So, that should be consider for wide range of liquid flow rates. So, in this case we have two type of design. First is the orifice type in this liquid flows through the holes in the plate and gas through the short stand pipes that we will see in the schematic also in next slide.

So, gas pipe should be size to give sufficient area for gas flow without creating a significant pressure drops because in this case both liquid and gas should pass through different holes. Further, if I consider the weir type liquid distributor in this liquid flows over notched weirs in the gas stand pipe and this type can be designed to cope with the wider range of liquid flow rates then can be considered in orifice type.

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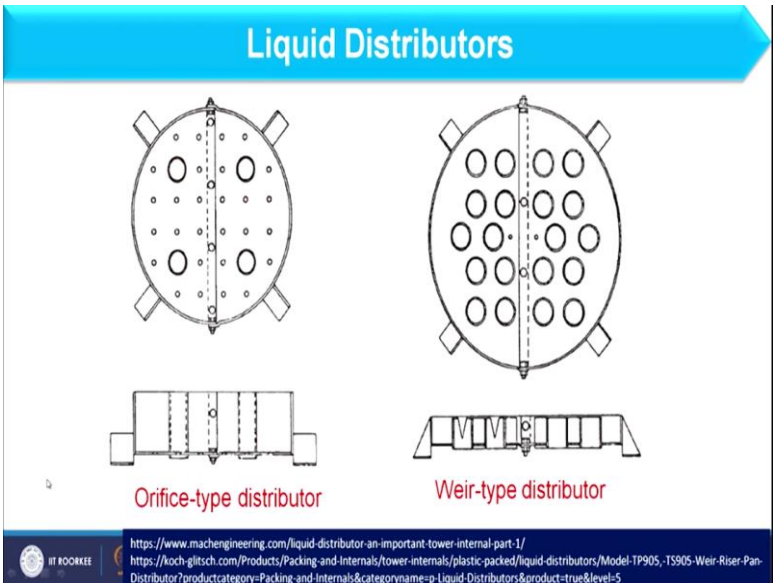

So, let us see here this is basically orifice type distributor where liquid will pass through from this small holes. However, these pipes are basically used for gas to move. So, these pipes are having some height however these holes are simply available on the plate and this is basically the weir type distributor where whatever pipes are available for gas it has a notch.

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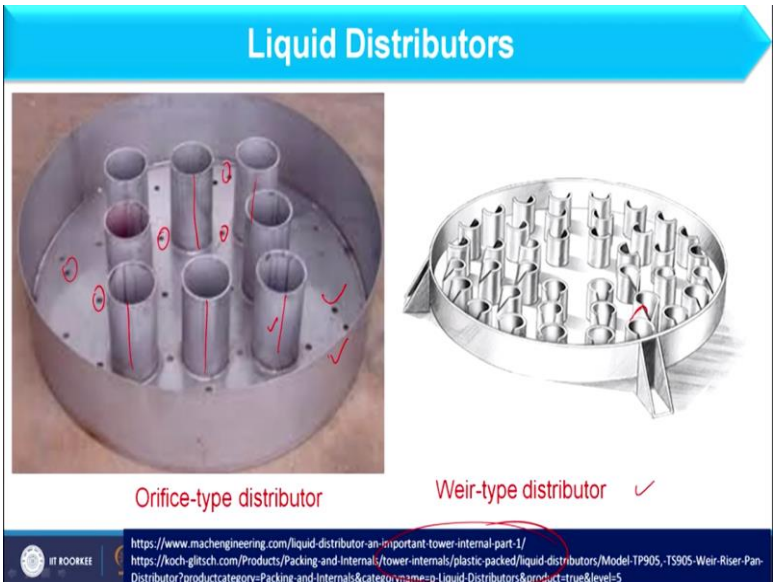

So, if we consider the proper images or photographic view of this it will be more clear like you see here we have the orifice type distributor where these holes are available in the plate through which liquid can pass and through this pipes of a definite pipe gas will pass. So, moment of gas as well as liquid is different over here and similarly in the weir type distributor liquid can pass through these notches also because when the liquid will be available over here it can pass through these notches, however, gas will also pass through this.

So, in this way we consider the weir type distributors about this you can study more in these references.

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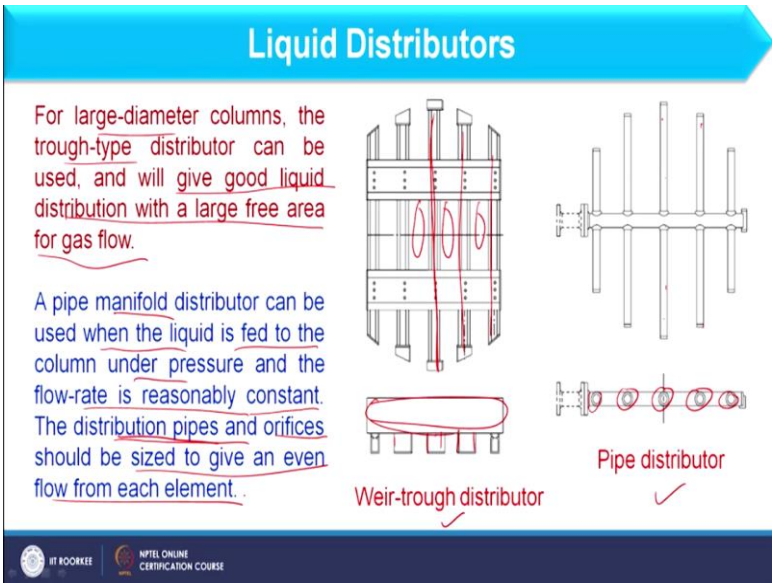

And now we have some more types of liquid distributor such as for larger diameter column the trough type distributor can be used and will give good liquid distribution with a large free area for gas flows. So, if you consider here we have the gas flow opening, however, liquid distribution can be done with these pipes also. So, that is basically trough type of distributor. So, here we have weir trough distributor where you can see this is the distributor plate and here we have weir type of structure.

So, in this we can have the holes along the length and in the similar line I am having pipe distributor and in this pipe we have different holes as you can see over here and through these holes liquid is properly distributed across the cross sectional area of the column. So, pipe manifold distributor can be used when the liquid is fed to the column under pressure and flow rate is reasonably constant.

The distribution pipe and orifices should be sized to give an even flow from each element. So, in this way we can consider distribution of liquid properly in larger diameter column and now we consider liquid redistributors. What is this liquid redistributor? If I consider the top of the column there we have the liquid distributor and then it covers the whole packing and if the height of the column is very large we can understand that packings are provided in some sections.

So, in one section liquid is distributed from the top and it properly covers the whole diameter after that and before starting the second set of the packing there we again have to redistribute the liquid throughout the column diameter. So, from one stack it will exit liquid will exit as it is and then it will be redistributed before entering into the second stack of the packing.

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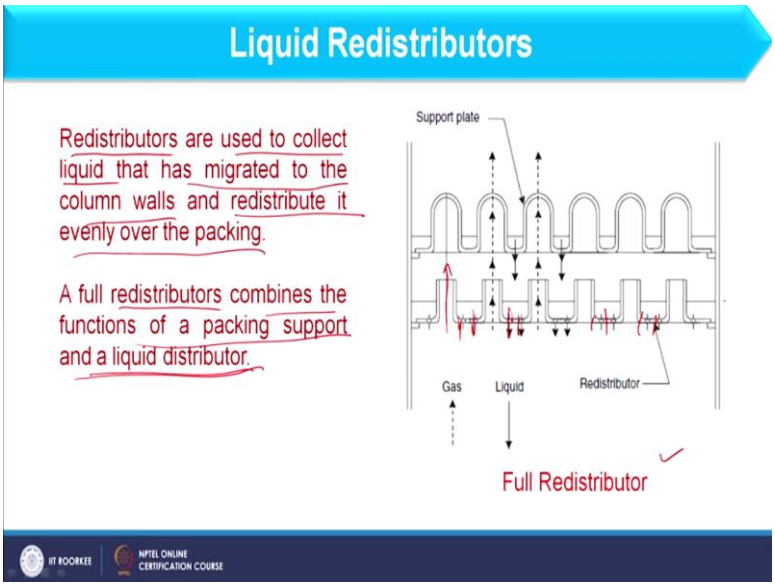

So, in this way redistributors are used and these are basically considered to collect the liquid that has migrated to the column walls and redistribute it evenly over the packing. So, it basically collects a liquid and redistribute it again. A full redistributors combines the functions of a packing support and liquid distributor. So, you can consider here we have the full redistributor and here we have the nozzle for the proper distribution.

And we can consider the gas moment as well as liquid moments from these sections. So, in this way this redistributor works as a support plate also as well as liquid distributor also.

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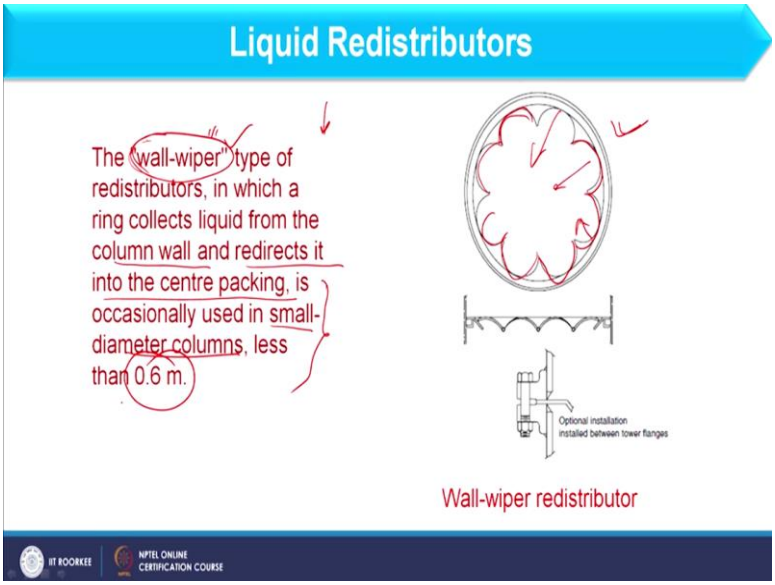

And now we have another type of liquid redistributor here we have wall wiper type redistributor as the name says it is wall wiper it means it is attached to the wall of the column and wipe the liquid inside the column. So, in which ring collects the liquid from the column wall and redirects it into the center packing. If you consider this schematic at the periphery we have this type of arrangement which we consider as the ring which collects the liquid and directs it towards the center.

So, such type of redistributor is used in small diameter column when the diameter is less than 0.6 meter. So, in this way we can consider liquid distributor and redistributors.

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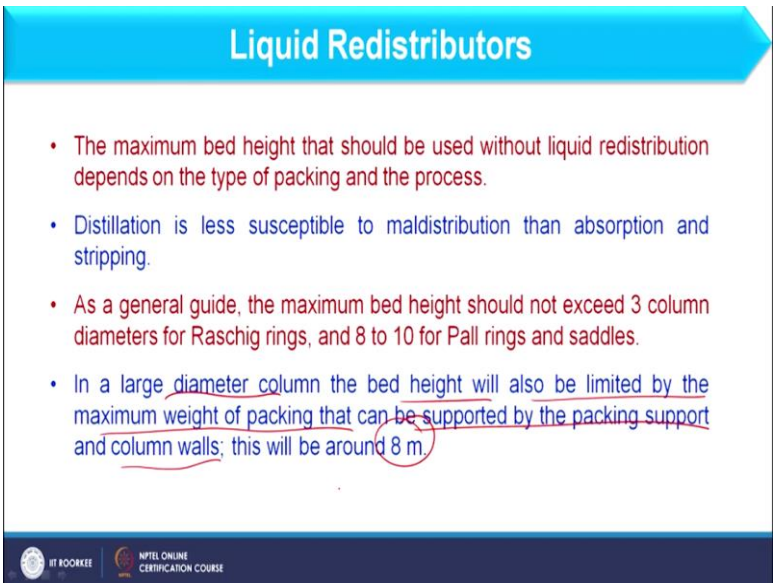

And now we have few more points about the liquid redistributor. In this the maximum bed height that should be used without liquid redistributor depends on the type of packing and the

process. So, depending upon the packing type and the size of the packing and process the height of the liquid distributor whether liquid redistributor is required or not that we can decide.

When we consider the distillation column it is less susceptible to maldistribution than absorption and stripping. What is maldistribution? When distribution is not proper so that we face more in absorption and stripping column with respect to distillation column. So, as a general guide the maximum bed height should not increase three column diameter for Raschig rings and 8 to 10 for Pall rings and saddles.

So, here you can consider the guideline that L / D it means L for the packing by dia. So, this ratio should be less than or equal to 3 when it is Raschig rings or we can consider it is between 8 to 10 for Pall rings and saddles. However, in the large diameter column the bed height will also be limited by the maximum weight of the packing that can be supported by the packing support and column walls and will be around 8 meter.

So, here I am having some guidelines which tells that where we should put liquid redistributors.

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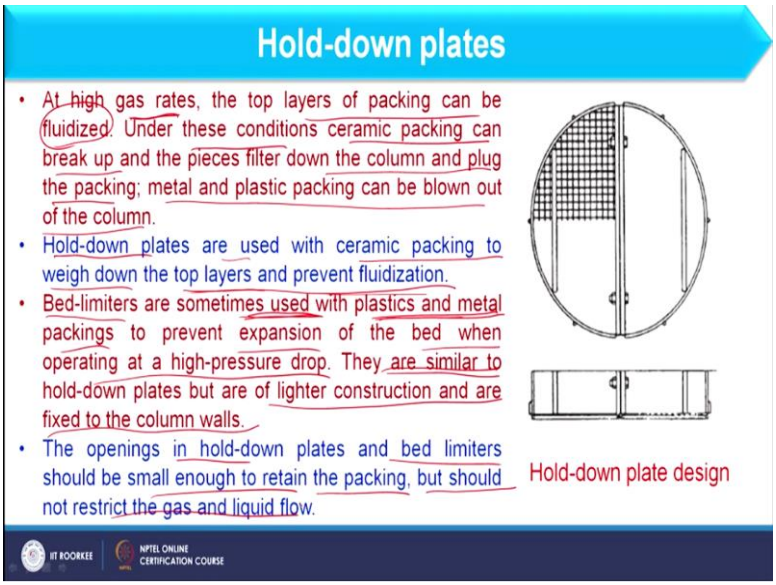

So, next we should consider the hold down plates. Now, what is this hold down plate? So, if we consider the packing then what will happen because gas is continuously coming from the bottom. So, what will happen it sometimes carries the packing with it if packing weight is less if we compare the metal as well as ceramic the ceramic packing is having lesser weight

and it basically carries with the gas which is not desirable for the proper operation of the packed column.

In this case we basically try to hold the packing from the top because gas is continuously moving from the bottom and the assembly through which it is done this is basically called as hold down plate. So, let us see a few points about that at high gas weights the top layer of packing can be fluidized that we just have discussed. Under these conditions, ceramic packing can be breakup and pieces of that filter down the column and plug the packing.

Metal and plastic packing can be blown out of the column also. So, in this way high gas velocity should not be used, but that we cannot do. However, we can hold the packing within the column by some means. In that case hold down plates are used with ceramic packing to way down the top layer and prevent fluidization of these packings. Further, we can have bed limiters.

And these are sometimes used with plastics and metal packings to prevent expansion of the bed when operating at high pressure drop. So, they are similar to the hold down plates, but are of lighter construction and are fixed to column walls. So, instead of hold down plates we can also use bed limiters and the openings in the hold down plates and bed limiters should be small enough to retain the packing, but should not restrict gas and liquid flow.

So, in this way we basically hold the packing within the column and so it is done through hold down plates or bed limiters. If you focus on the column internals it is showing properly in this image.

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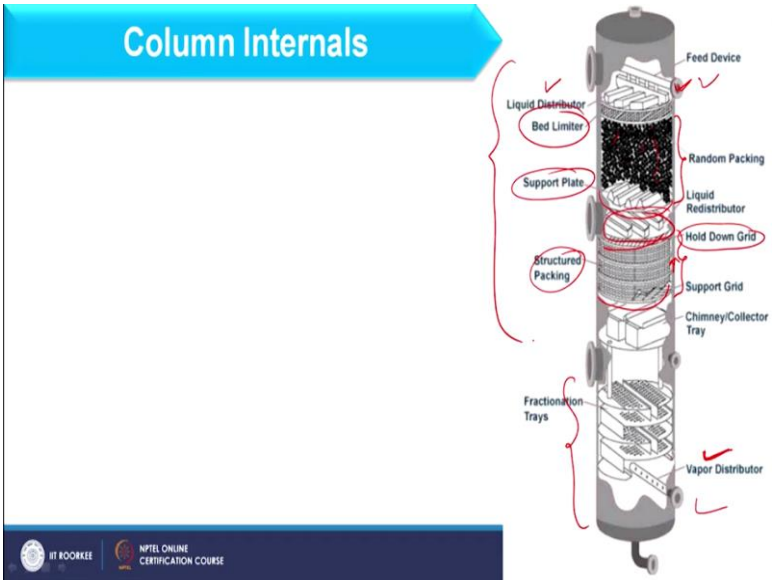

And if you see here I am having the top of the column and bottom of the column is shown over here. So, here we have vapour distributor and at top we have liquid distributor and then we put a bed limiter which does not allow the bed to expand and after that we can put the random packing and below the random packing support plate should be used. And if you see here I am having the liquid distributor up to here the liquid will be distributed and after that packing is not available.

So, liquid redistributor is used again to let the liquid enter into the second section of the packing and in this case we consider structured packing and at the top of this we have consider hold down grid which does not allow this bed to expand and blow out of these packing with the gas. At the bottom we consider the support grid and similarly we can have other assembly like here you see here basically the tray column and at the above we have packed column.

So, in this way two columns can be combined together. So, in this way you can consider different column internals and further we will discuss liquid hold up.

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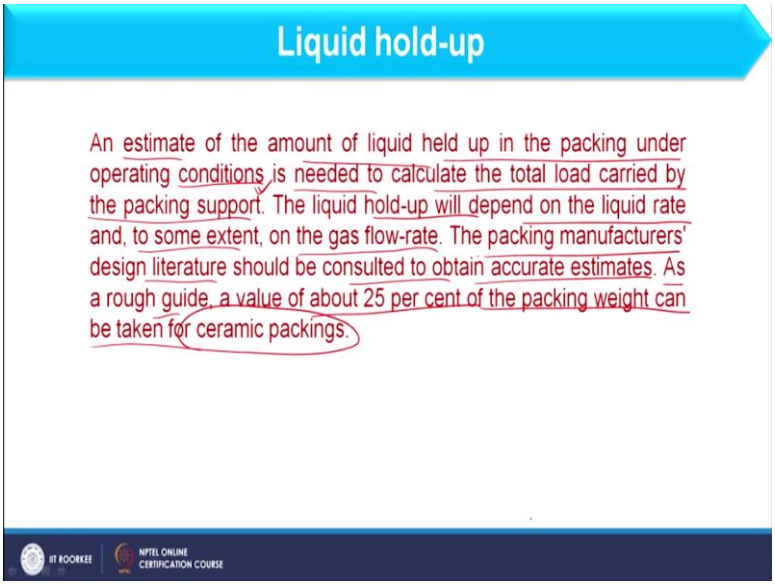

So, what it is an estimate of the amount of liquid held up in the packing under operating conditions is needed to calculate total load carried by the packing support. So, as we have discussed previously that packing support not only support the packing not only bear the weight of the packing, but also bear the weight of the liquid also. So, the liquid hold up will depend on the liquid flow rate and to some extent on the gas flow rate.

The packing manufacturers design literature should be consulted to obtain accurate estimate as a rough guide a value of about 25% of the packing weight can be taken for the ceramic packing. So, basically what is 25%? So, this 25% is basically the liquid hold up for ceramic packings and now we have another parameter that we call as wetted rates.

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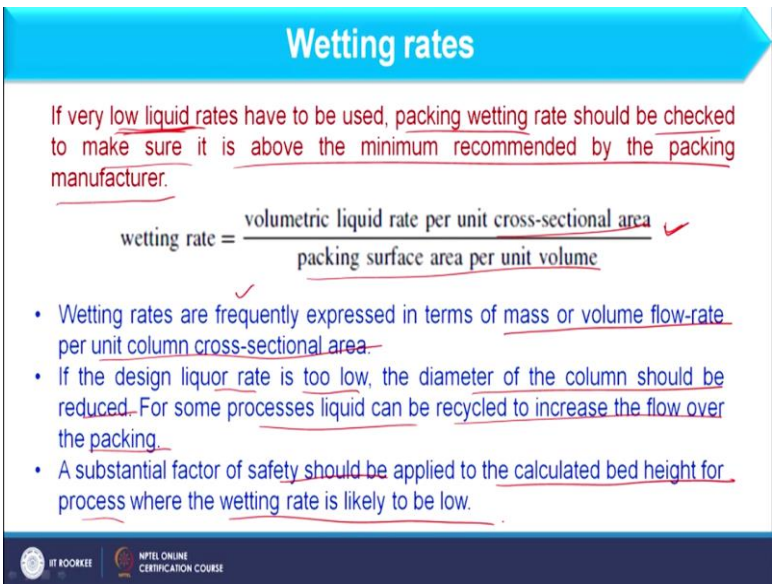

So, what is that wetted rates? This is basically the volumetric liquid rate per unit cross sectional area divide by the packing surface area per unit volume. So, if we consider this it should come out as the unit length per second. So, if we consider low liquid rate and that is basically very low liquid rate packing wetting rate should be checked to make sure that it is above the minimum recommended by the packing manufacturer.

So, wetting rates means how the packing is wetted by the liquid so that should be properly done and it is more desirable to check when I am considering very low flow rate of liquid. So, wetting rates are frequently expressed in terms of mass or volume flow rate per unit column cross sectional area as we have just discussed. If the design liquor rate is too low the diameter of the column should be reduced.

For some processes liquid can be recycled to increase the flow over the packing. So, this can also be done a substantial factor of safety should be applied to the calculated bed height for process where wetted rate is likely to be low. So, all these points we should consider and accordingly we should design the column internals.

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And here you have some of the references where you can find the details about this lecture.

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And here we have the summary of this video and it goes as column internals and packing support are discussed here. Liquid distributors and redistributors are discussed. Structure of hold down plates are described and finally we have considered liquid hold up and wetting rates. So, in this way you can consider column internals and that is all for now. Thank you.